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(54) **ANTIPYRETIC AND ANTI-INFLAMMATORY PEPTIDES.**

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J. Rheumatol., vol. 12, no.5, October 1985;
C.W. Denko et al.: "Effects of peptide hor-
mones in urate crystal inflammation", pages
971-975

(56) References cited :
Peptides, vol. 5, no. 4, 1984, Ankho Inter-
national Inc., US; D.B. Richards et al: "Effects
of alpha-MSH 11-13(lysine-proline-valine) on
fever in the rabbit", pages 815-817
The Journal of Immunology, vol. 137, no.7, 1
October 1986, American Association of Im-
munologists, US; J.G. Cannon et al.: "Alpha
Melanocyte stimulating hormone inhibits im-
muno-stimulatory and inflammatory actions of
interleukin 1", pages 2232-2236

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Description

This invention relates to a new pharmaceutical composition useful for the treatment of pyrexia and inflammation. More particularly, this invention relates to a tripeptide sequence contained in alpha-Melanocyte Stimulating Hormone and ACTH which has been identified as an antipyretic and anti-inflammatory agent.

There are two classes of agents presently in common usage as antipyretic agents, the salicylates and the para-aminophenol derivatives. The salicylates, characterized by acetylsalicylic acid (i.e., aspirin®), are the most extensively employed antipyretic agents. Aspirin® is the prototype for both the salicylates and other drugs with similar effects and is the standard of reference for comparison and evaluation of these agents. The antipyretic effect of aspirin® is usually rapid and effective in febrile patients. The salicylates act to reset the "thermostat" for normal temperature.

Although aspirin® is generally well-tolerated by most individuals, a number of toxic side effects are associated with its use. Of particular concern is salicylate-induced gastric ulceration and sometimes hemorrhage. Exacerbation of peptic ulcer symptoms (heartburn, dyspepsia), gastro-intestinal hemorrhage, and erosive gastritis have all been reported in patients taking aspirin®. Other less common side effects include tinnitus and hearing loss, changes in acid-base balance and electrolyte pattern, and respiratory alkalosis. Although generally such side effects are not particularly dangerous, they tend to reduce patient compliance. Other salicylate derivatives, which are generally employed for their analgesic and/or anti-inflammatory activity, demonstrate increased toxicities relative to aspirin.

The para-aminophenol derivatives, acetaminophen and phenacetin, are alternatives to aspirin® for its analgesic and antipyretic uses. Acetaminophen has somewhat less overall toxicity and is generally preferred over phenacetin. Because acetaminophen is well-tolerated and lacks many of the undesired effects of aspirin, it has been gaining favor as the "common household analgesic." However, its suitability for this purpose is questionable: in acute overdosage, acetaminophen can cause fatal hepatic necrosis. In addition, phenacetin may cause methemoglobinemia and hemolytic anemia as a form of acute toxicity, but more commonly as a consequence of chronic overdosage. These agents are about equipotent with aspirin in the treatment of pyrexia.

Recent advances in the study of alpha-Melanocyte Stimulating Hormone (hereinafter referred to as "MSH") have demonstrated that this protein is active in the treatment of pyrexia. Alpha MSH is a 13-amino acid peptide derived from Adrenocorticotrophic Hormone ("ACTH"). Both MSH and ACTH share a 13-amino acid sequence that is effective in modulating body temperature. There is evidence that these neuropeptides can influence centrally mediated processes, including central control of body temperature. Both peptides lower core temperature of afebrile rabbits when given peripherally or centrally in sufficient dosages. Much smaller dosages reduce fever without altering normal temperature.

Alpha MSH is found in brain regions that govern temperature regulation, including the anterior hypothalamus and the septum. The concentration of alpha MSH in the septum rises during fever, and the concentration in the arcuate nucleus tends to decline at the same time. Studies comparing the antipyretic activity of centrally-administered alpha MSH to the widely-used antipyretic, acetaminophen indicate that alpha MSH is much more potent in reducing fever than acetaminophen, and that alpha MSH was more than 2500 times more potent by weight than acetaminophen in reducing fever. No endogenous substance other than ACTH is known to have such potency in reducing fever.

The antipyretic potency of alpha MSH and the fact that this peptide reduces fever even when given peripherally may have clinical significance.

In the state of the art it was already known that ACTH (Human Adrenocorticotrophic Hormone) may be used to reduce clinical and experimental fever. ACTH which corresponds to amino acids 1 to 39 of proopiomelanocortin was also known to be active in the treatment of inflammation. This activity is a consequence of the corticosteroid stimulatory effect of ACTH, which upon repeated administration may result in Cushing's syndrome as an undesired side effect.

From Document 1 (J. Rheumatol. 12 (1985), pages 971-975), it was already known that a shorter ACTH derived peptide, alpha-MSH (amino acids 1 to 13 of ACTH) has the effect of diminishing swelling when injected along with urate crystals into the hind paw of rats. This article does not reveal whether any peptidyl subportions of the peptide will be useful in addressing inflammation and, in fact, appears to suggest that longer chain peptides tend to be anti-inflammatory, while shorter chain compounds tend to promote inflammation (see column 1, page 975).

Document 2 (Peptides, Vol. 5 (1984), pages 815-817) discloses the use of the tripeptide Lys-Pro-Val for the reduction of fever in rabbits either after central or peripheral administration. This article does not discuss or suggest any effect of the tripeptide in the treatment of inflammation.

The present invention provides the use of the tripeptide sequence Lys-Pro-Val in the preparation of a peptide for use as a medicament for treating inflammation.

The present invention provides a pharmaceutical composition useful in the treatment of pyrexia and inflammation. The active component of this pharmaceutical composition is a peptide which is an amino acid sequence corresponding to amino acids 11 through 13 of alpha MSH, lysine-proline-valine ("lys-pro-val").

5 Preferably, the tripeptide itself is administered to achieve maximal benefits in accordance herewith, preferably in a biologically "protected" form. When the tripeptide is "protected" through acylation of the amino terminus and/or amidation of the carboxyl terminus, the resulting tripeptide demonstrates an increase in pharmacologic activity.

In the present specification and claims the use for the production of a medicament is described to treat pyrexia and/or inflammation in an individual in need of such treatment in which an effective dose of a peptide 10 which includes the tripeptide sequence is administered to an individual, having an inflammation. That means that, such peptides may be used in the treatment of both generalized or localized inflammation and, therefore, is a useful alternative to steroidal and salicylate anti-inflammatory agents. Anti-inflammatory activity is observed following administration of the tripeptide to animals at doses approximately equal or greater than those used to demonstrate antipyresis, and testing the reactivity of treated and control animals to inflammatory challenge. 15 Therefore, the peptides of the present invention may be used both as an antipyretic (which is not part of the invention) and as an anti-inflammatory agent when administered at a selected dose to a patient in need.

In particular embodiments herein, doses of the tripeptide effective for the expression of anti-inflammatory activity, for example, for the reduction of inflammation-associated swelling and/or capillary permeability, are shown to be roughly similar on a weight basis to those of hydrocortisone, an accepted standard for anti-inflammatory activity. 20 The sensitive "skin-blueing" assay was employed to test the ability of the tripeptide to inhibit the capillary permeabilizing effects of inflammatory agents such as histamine. In this assay, the protected Lys-Pro-Val tripeptide exhibited antihistamine effects, and in particular, a reduction in histamine-mediated increases in capillary permeability, at intravenous dosages as low as 1.25 µg protected tripeptide/kg body weight. Moreover, in the traditional carrageenan/rat paw edema test, intraperitoneally-administered tripeptide demonstrated an ability to inhibit carrageenan-induced swelling of rat paws on a per weight basis commensurate with 25 hydrocortisone. Accordingly, from such observations it can be concluded that the tripeptide lys-pro-val is an effective anti-inflammatory when administered to a patient at a dose ranging from as low as 1 to 10 µg/kilogram, to preferred ranges of on the order of 0.2 to 3 mg/kg/day.

Figure 1. Amino acid sequence of alpha-MSH

30 Figure 2. Comparison of inhibition of paw swelling caused by Ac-Lys-Pro-Val-NH₂ (100 mg/kg) and hydrocortisone (100 mg/kg) in rats. Each score is the mean % change in paw volume relative to the change in matched control paw volume.

The tripeptide sequence of lysine-proline-valine is characterized as follows.

In its naturally occurring form, the tripeptide sequence (lysine-proline-valine) comprises amino acid numbers 11-13 of alpha-Melanocyte Stimulating Hormone (hereinafter "MSH") and ACTH. This finding may explain 35 the antipyretic activity of the amino-terminal portion of ACTH (amino acid numbers 1-24 of proopiomelanocortin) and MSH (amino acid numbers 1-13 of ACTH and proopiomelanocortin; see Figure 1), both of which exhibit the tripeptide sequence within their structure. Therefore, both MSH and ACTH represent potential naturally occurring sources from which the antipyretic tripeptide can be obtained, or, in the case of alpha-MSH, which can be used directly 40 in accordance with less preferred embodiments.

Due to the high corticotropic effect of ACTH, which can lead to incidences of Cushing's Syndrome, the invention is generally directed to the alpha-MSH sequence and peptides thereof, so long as such peptides include at least the lys-pro-val sequence. This is based on the finding that alpha-MSH (amino acids 1-13 of ACTH) does not exhibit the corticotropic effect of ACTH and, instead, appear to exert their anti-inflammatory 45 action directly rather than through a corticosteroid intermediate.

In a preferred embodiment, the tripeptide can be isolated from MSH. This can be accomplished by first fragmenting the MSH protein into four smaller peptides through total digestion with the proteolytic enzyme, chymotrypsin. Paper electrophoresis of the digestion products reveals four major products, one of which is the tetrapeptide, glycine-lysine-proline-valine, which may be used directly. However, the glycine residue can be 50 removed by partial acid hydrolysis to yield the tripeptide.

The peptide in accordance with the invention can also be obtained by chemical synthesis. This is accomplished by way of peptide bond formation between the appropriate amino acids. Amino acids are amphoteric molecules which contain both an acidic (-COOH) moiety and a weakly basic (-NH₂) moiety. Peptide bond formation (-CONH-), therefore, is accomplished through a nucleophilic attack of the amine group on the carboxylic 55 function.

In forming a peptide bond between two hypothetical amino acids, X and Y, four possible dipeptides may be produced: X-Y, Y-X, Y-Y, and X-X. Therefore, in order to reduce the possible structures that may be formed in such an interaction, the amino or carboxy terminus of the appropriate amino acid must be first "protected"

so as to preclude a reaction involving the "protected" moiety. For example, if "c" represents a protected carboxy terminus and "n" a protected amino terminus, then an interaction involving cX and Yn could generate only one structure, cX-Yn.

However, in order to be chemically useful for synthetic purposes, the protecting groups must be removable. In general, carboxy groups can be protected by esterification or amidation of the -COOH to -COO-alkyl or -CONH₂. The preferred alkyl groups for the carboxy terminus include methyl and benzyl residues, yet other alkyl groups, such as ethyl, propyl, butyl, p-nitrobenzyl or p-methoxybenzyl groups, can be utilized.

Likewise, the amino terminus is protected by acylation, introducing a carboxyl group such as an acetyl group, t-butyloxycarbonyl group, t-amylloxycarbonyl group, o-nitrophenylsulfonyl group, benzyloxycarbonyl group, p-nitrobenzyloxycarbonyl group, tosyl or formyl group.

Protecting groups may also serve a function in nature. Bioactive peptides which contain an acetyl group bound to be amino-terminus of the peptide and an amido function bound to the carboxy-terminus are less susceptible to acid hydrolysis. Furthermore, it has been speculated that such groups play a role in reducing the susceptibility of the "protected" peptide to enzymatic attack and degradation. Accordingly, a "protected" tripeptide has been synthesized which contains these protecting groups. This protected tripeptide is more active pharmacologically than the unprotected tripeptide.

The various distinct pharmacological actions of the tripeptide, i.e., anti-inflammation and antipyresis, are demonstrated herein through the use of accepted pharmacological assays. For example, antipyretic action is demonstrated using an *in vivo* rabbit pyresis assay in which increasing amounts of a protected tripeptide (acetyl-lys-pro-val-NH₂) was administered to pyrogen-induced rabbits. In this assay, an effective dose range of on the order of 10 µg to 100 mg/kg for the unprotected tripeptide was observed, resulting in fever reductions over control of on the order of about 25% to about 70%, in a generally dose dependent fashion. Moreover, the protected tripeptide (diacetyl-lys-pro-val-NH₂) exhibited an activity approximately twice the activity of the unprotected species on a weight basis.

The anti-inflammatory action of the tripeptide is demonstrated employing accepted *in vivo* assays designed to test the ability of a test agent in inhibiting various symptomology of inflammation, including tissue swelling (e.g., localized edema) and capillary permeability.

In one assay, the skin-blueing test, the tripeptide was tested for its ability to inhibit the capillary permeabilizing effects of histamine by its action in blocking the effects of exogenous histamine. Using this assay, which has been found by the present inventors to be sensitive to low amounts of the agent, it was found that dosages as low as about 1 microgram of the protected tripeptide/kilogram elicited a demonstrable effect as measured by reduction in histamine-mediated increase of vascular permeability to vital dyes.

In a second test, referred to in the art as the carrageenan/rat paw edema assay, the tripeptide is shown to achieve an anti-inflammatory action roughly equivalent to that of a well-known anti-inflammatory agent, hydrocortisone. In this assay, rats were first administered equal intraperitoneal doses of either control (saline), of tripeptide or of hydrocortisone. The paw of the rat was then challenged with an antigenic substance, generally carrageenan, and the resultant swelling measured and data compared. From such assays, it was found that approximately equal weights of the protected tripeptide (diacetyl-Lys-Pro-Val-NH₂) and hydrocortisone resulted in a roughly equivalent overall response in reducing the degree of carrageenan-induced swelling.

Based on the foregoing and additional observations, it is found that dosages on the order of 0.2 to about 3 mg of protected tripeptide per kilogram body weight per day will result in advantages in accordance with the present invention in terms of effective anti-inflammatory action. Generally, it will be preferred to administer doses of on the order of 0.35 and about 1.5 mg of protected tripeptide/kg body weight/day to achieve the greatest degree of anti-inflammatory benefit. These dose ranges are derived from the aforementioned observation of approximately equipotency of the tripeptide and hydrocortisone, and the general knowledge in the art regarding effective dose ranges of hydrocortisone (see, e.g., Goodman et al. (1985), The Pharmacological Basis of Therapeutics, 7th Edition).

In accordance with the invention, it will generally be preferred to administer the tripeptide parenterally, for example, intramuscularly or intravenously. However, due to its small size, membrane permeability and relatively acid-stable structure, it will be recognized that the tripeptide may be administered orally, albeit at somewhat higher doses. In this regard, it is believed that doses of on the order of approx. 0.2 to approx. 3.5 mg/kg/day will achieve benefits in accordance herewith.

Pharmaceutical preparations of the tripeptide, preferably a protected tripeptide such as diacetyl-Lys-Pro-Val-NH₂, comprise generally the active agent in combination with pharmaceutically acceptable buffers, diluents, stabilizers and the like. For a fairly complete listing of various techniques, including a variety of agents and additives useful in the preparation of acceptable pharmaceutical compositions, one may wish to refer to Remington's Pharmaceutical Sciences, 16th ed., 1980, Mack Publishing Co., incorporated herein by reference.

In a preferred pharmaceutical composition, approximately 100 to 500 mg of diacetyl-Lys-Pro-Val-NH₂ is

dispersed in about 1 to 7 cc. of sterile isotonic saline, including a pharmacologically accepted buffer to maintain a pH of about neutral. For intravenous administration, for example, to a patient suffering from arthritis, or severe allergic reaction or various other diseases involving inflammatory processes, it will generally be desirable to administer approx. 0.2 to approx. 3.5 mg/kg/day of the agent by slow infusion over a period of time (up to several hours). Where infusion is impractical, the agent is administered in the form of an intramuscular injection, preferably in combination with a lipophilic carrier and at somewhat higher doses. For the treatment of mild to severe arthritic episodes, it is generally recommended that a parental dose of on the order of approx. 0.3 to 1.5 mg/kg/day, preferably approx. 0.5 to approx. 0.6 mg/kg/day. However, for severe allergic reactions, higher doses on the order of approx. 2.5 to up to approx. 4 mg/kg/day may be indicated.

It is believed that many changes may be made in the amino acid sequence of the peptides of the present invention and still obtain a protein which exhibits a biologically functional equivalent pharmacologic activity. For example, it has been found by Kyte et al. (1982), *J. Mol. Biol.*, 157:105, that certain amino acids may be substituted for other amino acids having a similar hydropathic index, and still retain the biological activity of the protein. As displayed in the table below, amino acids are assigned a hydropathic index on the basis of their hydrophobicity and charge characteristics. It is believed that the relative hydropathic character of the amino acid determines the secondary structure of the resultant protein, which in turn defines the interaction of the protein with its receptor.

<u>Amino acid</u>	<u>Hydropathic Index</u>
Isoleucine	4.5
Valine	4.2
Leucine	3.8
Phenylalanine	2.8
Cysteine/cystine	2.5
Methionine	1.9
Alanine	1.8
Glycine	-0.4
Threonine	-0.7
Tryptophan	-0.9
Serine	-0.8
Tyrosine	-1.3
Proline	-1.6
Histidine	-3.2
Glutamic Acid	-3.5
Glutamine	-3.5
Aspartic Acid	-3.5
Asparagine	-3.5
Lysine	-3.9
Arginine	-4.5

The following examples illustrate experiments conducted by the present inventor to illustrate the production of the preferred tripeptide, as well as various "protected" species, and use of the tripeptide in various accepted *in vivo* assays which demonstrate its activity. It will be appreciated that these examples are illustrative for the present invention.

The tripeptide used in the examples described below was custom synthesized by Bachem, Inc., Torrance, Ca., as follows:

Example I. Z-Lys-Pro-OMe Preparation

50 mmoles (20.7 grams) of dibenzylloxycarbonyl-conjugated lysine ("Z-lys") in 200 ml of methylene chloride was combined with 50 mmoles (8.3 grams) of proline methyl ester (pro-OMe) in 100 ml dimethyl formamide. The mixture was added to a conical flask and cooled to -5°C with stirring. 50 mmoles (5.5 ml) of N-methyl morpholine was added, followed by the addition of 10.3 grams of dicyclohexyl-carbodiimide in 20 ml of methylene chloride and the reaction mixture was stirred overnight. The mixture was then filtered from urea and the filtrate concentrated in vacuo. The residue was taken up in ethyl acetate and washed successively with sodium bicarbonate solution, water, 1N hydrochloric acid, and water. Ethyl acetate was removed in vacuo and the oily product was saponified without purification.

2. Removal of the -OMe Carboxy Terminus "Protecting" Group.

The oily product from the previous experiment was dissolved in methanol (200 ml) and treated with 2N sodium hydroxide (25ml) for an hour. Methanol was removed under reduced pressure and the residue was taken up in water and acidified with 6N hydrochloric acid. The product was extracted with ethyl acetate, and the organic layer was washed with water and dried over sodium sulphate. Ethyl acetate was removed in vacuo and the residue was triturated with hexane. The product was checked by thin layer chromatography using chloroform: methanol: acetic acid (95:4:1).

3. Preparation of Z-Lys-Pro-Val-OBz

The next step in the synthesis of the tripeptide involved the addition of a carboxy-protected valine residue (Val-OBz). The protecting group in this instance was a benzyl ester. 37 mmoles (19 grams) of Z-Lys-Pro obtained from step 2 above was dissolved in 200 ml distilled tetrahydrofuran. This solution and 4.1 ml N-methyl morpholine were mixed together and cooled to -15°C with stirring. Isobutylchloroformate (5)(ml) was added and the mixture stirred for 5 minutes at -10°C. Concurrent with the above, 35 mmoles (13.2 grams) of valine benzyl ester tosylate was dissolved in 100 ml dimethyl formamide. The mixture was cooled to -10°C and neutralized with N-methyl morpholine (4ml). This was added to the above mixed anhydride and stirred overnight. The mixture was then filtered from urea and the filtrate concentrated in vacuo. The residue was taken up in ethyl acetate and washed successively with sodium bicarbonate solution, water, 1N hydrochloric acid, and water. The crude product was purified on a silica gel column using chloroform-methanol (95:5). Fractions containing the pure product were determined by thin layer chromatography utilizing the same solvent as for step 2. The appropriate fractions were pooled.

4. Removal of the Protecting Groups Z- and -OBz

9 grams of the protected tripeptide produced in step 3 above was hydrogenated in an acetic acid-water-methanol mixture in the presence of Pd/BaSO₄ overnight. It was filtered from the catalyst and the filtrate was evaporated in vacuo to give an oily residue. This was triturated with absolute ethanol and absolute ether to yield 3 grams of the crystalline product. The product was checked by thin-layer chromatography using a solvent system composed of butanol: acetic acid: water: pyridine (20:6:11:24).

Chemical Synthesis of diacetyl-L-Lysyl-L-Prolyl-L-Valyl-NH₂

The protected tripeptide, diacetyl-L-Lysyl-L-Prolyl-L-Valyl-NH₂ can also be prepared by the chemical techniques described above in steps 1-3. For example, in step 1, the starting material would be diacetyl conjugated lysine. In step 3, the valine-benzylester is substituted with valyl-amide.

EXAMPLE II: ANTI-INFLAMMATORY ACTIVITY

The anti-inflammatory activity of the tripeptide was demonstrated through the use of an animal model developed by Sparrow and Wilhelm (1957), *J. Physiol.*, 137:51-65, incorporated herein by reference. This model relies on the principal that localized, subcutaneous injections of histamine will result in a localized increase in capillary permeability. When the test animal has been pretreated with blue dye intravenously, the localized histamine injections will elicit blue-colored "weals" around the injection site. Thus, by preadministration of an effective anti-inflammatory agent, the blue color of the histamine-induced weals will be much less pronounced, with the amount of color reduction being dependent on the relative amount and/or potency of the

anti-inflammatory agent used.

Non-moulting New Zealand white rabbits were used for the Sparrow/Wilhelm assay. The skin of the rabbits back was closely clipped 1-2 days previous to the experiment, but not depilated, and the rabbits were kept warm until tested. Various amounts of the protected tripeptide (diacetyl-L-lys-L-Pro-L-Val-NH₂) were injected intravenously into an ear vein approximately 15 minutes prior to intravenous injection of blue dye. Control rabbits received sham injections. Fifteen minutes following injection of the agent or sham, the rabbits received approximately 30 mg/kg of Pontamine blue dye as a 2.5% solution in 0.45% saline, into an exposed vein.

Immediately following dye injections, histamine was injected intradermally in a 0.10 ml volume (1.25 mg histamine (0.1 ml volume) at several sites on each side of the spine. In all, one vertical row of six injections were made on each side of the spine. The relative intensity of the resultant blue weals were scored by an independent observer 30 minutes after histamine injection. The results are displayed in Table I below.

TABLE I: Anti-inflammatory Activity
of the Tripeptide

No. Animals Tested	Tripeptide Dose +	Result
3 (2E, 1C) *	5	E lighter than C
2 (1E, 1C)	10	E lighter than C
2 (1E, 1C)	5	E lighter than C
2 (1E, 1C)	1.25	E lighter than C
2 (1E, 1C)	0.625	No difference observed

* E = experimental; C = control

+ Dosages in ug of protected tripeptide per kg body weight, administered intravenously.

As will be appreciated from the results displayed in Table I, intravenous doses down to 1.25 µg tripeptide per kg body weight resulted in an appreciable reduction in histamine-induced blue weal formation and is thus indicative of an effective anti-inflammatory action. At doses of 5 and 10 µg/kg, the observed response was even more pronounced. Also as will be appreciated, the anti-inflammatory effect of the tripeptide is observed at relatively lower doses as compared to its anti-pyretic effect.

EXAMPLE III: CARRAGEENAN/RAT PAW EDEMA ASSAY

A second *in vivo* bioassay for anti-inflammatory activity was conducted in which the action of the tripeptide was compared to that of hydrocortisone. In this assay, the two agents were given at similar doses and tested for their independent ability to inhibit carrageenan-induced swelling of rats paws. This assay, the rat paw edema test, was conducted generally as it is typically performed in the art, for example, as described by Winter et al.

(1962), *Proc. Soc. Exp. Biol. Med.*, 111:544 or in U.S. Patent 4,150,137.

Briefly, the assay was performed as follows. Each of twenty-four male Sprague-Dawley rats was assigned to one of four groups: tripeptide treatment and controls (matched according to body weight and initial paw volume), hydrocortisone treatment and matched controls. The volume of the right rear paw of the test and control animals was determined using standard procedures and a mercury displacement volumetric technique. An intraperitoneal injection of the tripeptide (Ac-Lys-Pro-Val-NH₂, 100 mg/kg, N=6), of hydrocortisone (100 mg/kg, N=6), or saline (matched volume, N=12) was given to each rat. One hour later 0.5 ml of 1 % lambda carrageenan in saline solution was injected into the right rear paw of the animals and the paw volume was again recorded (baseline measure). Thereafter paw volume was measured each hour for four hours. For comparison of the effects of the two treatments, paw volume of experimental animals measured at hourly intervals was expressed as a percentage of the volume change of their respective matched controls.

The results of this experiment is shown in Figure 2. As will be appreciated from this data, except for the first hour when hydrocortisone markedly inhibited swelling ($p < 0.05$, Mann-Whitney test), there was no significant difference in the inhibition of paw edema caused by the tripeptide and hydrocortisone ($p > 0.20$). These results indicated that the tripeptide inhibits inflammation as well as the classic anti-inflammatory agent, when given in an equal dose by weight, albeit with a slight difference in time course. Based on the present results and the known effects of hydrocortisone and inflammation in man, it is concluded that the tripeptide Lys-Pro-Val can be used to reduce inflammation in man, in dosage not markedly different from that of hydrocortisone.

The foregoing invention has been described by way of illustration and examples and in terms of standard laboratory techniques employed by the applicant.

Moreover, it will be apparent that administration of any copper salt, whether it be the sulfate, chloride, or some other similar copper salt, should be as active as the chloride salt in augmenting the activity of the tripeptide.

25 Claims

1. The use of the tripeptide sequence Lys-Pro-Val for the production of a medicament for treating inflammation.
2. The use of claim 1 wherein the peptide is the tripeptide Lys-Pro-Val.
3. The use of claim 2 wherein the tripeptide is protected at its amino or carboxy terminus.
4. The use of claim 3 wherein the protected tripeptide is acylated at its amino terminus or amidated at its carboxy terminus.
5. The use of claim 3 wherein the protected tripeptide is acylated at its amino terminus and amidated at its carboxy terminus.
6. The use of claim 3 wherein the protected tripeptide is acetylated at its amino terminus and amidated at its carboxy terminus.

40 Patentansprüche

1. Verwendung der Tripeptidsequenz Lys-Pro-Val zur Herstellung eines Medikaments zur Behandlung von Entzündungen.
2. Verwendung nach Anspruch 1, wobei das Peptid das Tripeptid Lys-Pro-Val ist.
3. Verwendung nach Anspruch 2, wobei das Tripeptid an seinem Amino- oder Carboxyterminus geschützt ist.
4. Verwendung nach Anspruch 3, wobei das geschützte Tripeptid an seinem Aminoterminus acyliert ist oder an seinem Carboxyterminus amidiert ist.
5. Verwendung nach Anspruch 3, wobei das geschützte Tripeptid an seinem Aminoterminus acyliert ist und an seinem Carboxyterminus amidiert ist.
6. Verwendung nach Anspruch 3, wobei das geschützte Tripeptid an seinem Aminoterminus acetyliert ist und an seinem Carboxyterminus amidiert ist.

55 Revendications

1. L'utilisation de la séquence du tripeptide Lys-Pro-Val pour la fabrication d'un médicament anti-inflammatoire.

2. L'utilisation de la revendication 1 dans laquelle le peptide est le tripeptide Lys-Pro-Val.

3. L'utilisation de la revendication 2 dans laquelle le tripeptide est protégé à son extrémité aminée ou carboxy.

5 4. L'utilisation de la revendication 3 dans laquelle le tripeptide protégé est acylé à son extrémité aminée ou amidé à son extrémité carboxy.

5. L'utilisation de la revendication 3 dans laquelle le tripeptide protégé est acylé à son extrémité aminée et amide à son extrémité carboxy.

6. L'utilisation de la revendication 3 dans laquelle le tripeptide protégé est acétylé à son extrémité aminée et amidé à son extrémité carboxy.

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AMINO ACID SEQUENCE OF ALPHA-MSH

NH₂ - SERINE - TYROSINE - SERINE -
METHIONINE - GLUTAMIC ACID -
HISTIDINE - PHENYLALANINE -
ARGININE - TRYPTAMINE -
GLYCINE - LYSINE - PROLINE -
VALINE - COOH

Fig. 1

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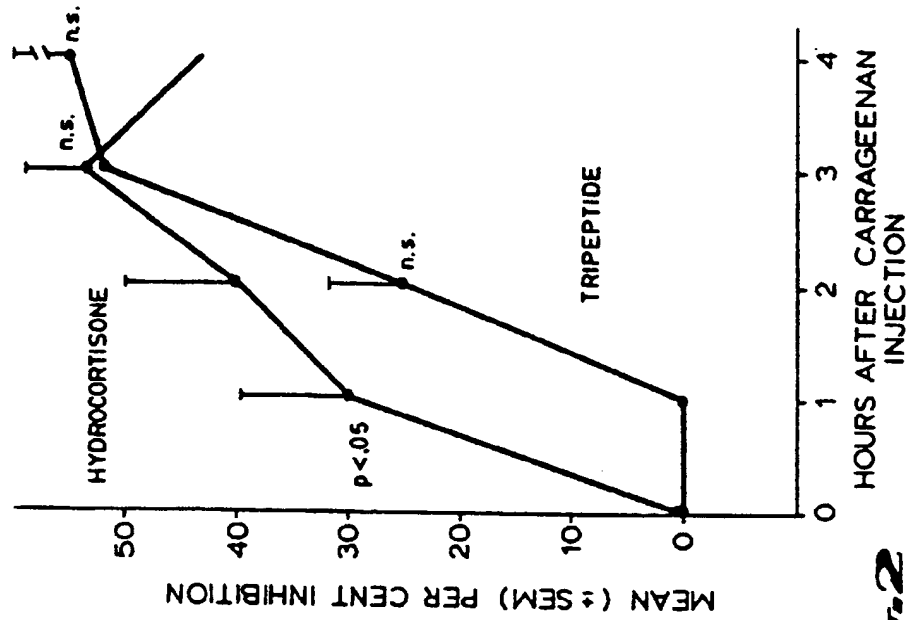


Fig. 2